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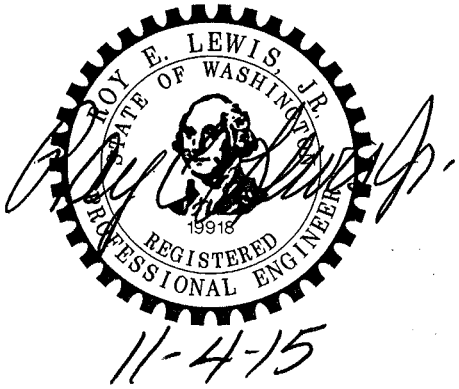
MEMORANDUM

Date:	November 4, 2015
To:	Rob Jammerman, PE
From:	Beau J. Willert, EIT
	(Reviewed by Roy E. Lewis, Jr., PE)
Re:	Bridlestone Estates -
	New Channel 100-year Flow Determination
Triad Job No.:	13-097
Copies To:	File



The purpose of this memorandum is to summarize the inputs and assumptions for the modeling of the 100-year flow associated with the area tributary to the proposed on-site new channel/culvert (fish-passage), that parallels 116th Avenue NE underneath the entrance to the proposed Bridlestone Estates site. This memorandum will also cover the flows calculated and the updated design in order to accommodate the analyzed 100-year flow. The calculations will be memorialized in revisions to the *Bridlestone Estates Preliminary Plat Technical Information Report* issued on December 15, 2014. A final copy of the Technical Information Report will be provided with the final engineering plans and will include this memorandum along with the associated inputs, assumptions and calculations.

After review of the Yarrow Creek Basin Report Card found in the City of Kirkland 2014 Surface Water Master Plan, and examination of the existing topography provided by King County iMAP, it was found that the total basin tributary to the proposed fish-passage was 343.8 acres, producing a 100-year storm flow of 96.9 cubic feet per second. This tributary basin is a mixture of Roads, Forest and Existing Residential Areas. The current impervious/pervious area assumptions are provided below. Please refer to the *Tributary Area Exhibit* attached at the end of this memorandum.

Per the 2009 King County Surface Water Design Manual (2009 KCSWDM), Table 3.2.2.D Percent Impervious Coverage For Existing Residential Areas on page 3-28, the following impervious coverages were determined.

- Residential Area #1: 42% Impervious Coverage
  - 11.1 acres, 40 Dwelling Units, 3.6 Dwelling Units/Acre
- Residential Area #2: 38% Impervious Coverage
  - 1.8 acres, 6 Dwelling Units, 3.3 Dwelling Units/Acre
- Residential Area #3: 15% Impervious Coverage
  - 39.9 acres, 28 Dwelling Units, 0.7 Dwelling Units/Acre

- Residential Area #4: 20% Impervious Coverage
    - 18.9 acres, 26 Dwelling Units, 1.4 Dwelling Units/Acre
- Residential Area #5: 30% Impervious Coverage
    - 19.3 acres, 46 Dwelling Units, 2.4 Dwelling Units/Acre

- Bridlestone Estates: 25% Impervious Coverage
    - 17.6 acres, 35 Dwelling Units, 2.0 Dwelling Units/Acre

Existing major Roads include:

- NE 60th Street from 116th Avenue NE to just west of 126th Avenue NE.

- Half of 116th Avenue NE from just north of NE 60th Street to the sound edge of the Bridlestone Estates.

- Roadways in Existing Residential Areas are included in the 2009 KCSWDM Table 3.2.2.D Percent Impervious Coverage Calculations.

As stated above, the total basin area was a total of 343.8 acres. After analyzing each area land-use coverage the information was input into the King County Runoff Time Series (KCRTS) Version 6.0. The input from KCRTS is attached to the memorandum for reference.

After the 100-year annual peak flow was determined, Manning's Equation for channeled flow was used to define the necessary capacity of the fish-passage. It was found that a 2-foot tall by 12-foot wide bottomless fish-passage would provide the capacity needed to pass the 96.9 cubic feet per second, 100-year storm event.

Bridlestone Estates – Triad Job #: 13-097
Proposed Culvert Tributary Basin – 100-year Peak Flows

228.60	0.00	0.000000	Till Forest
0.00	0.00	0.000000	Till Pasture
83.30	0.00	0.000000	Till Grass
0.00	0.00	0.000000	Outwash Forest
0.00	0.00	0.000000	Outwash Pasture
0.00	0.00	0.000000	Outwash Grass
0.00	0.00	0.000000	Wetland
31.90	0.00	0.000000	Impervious

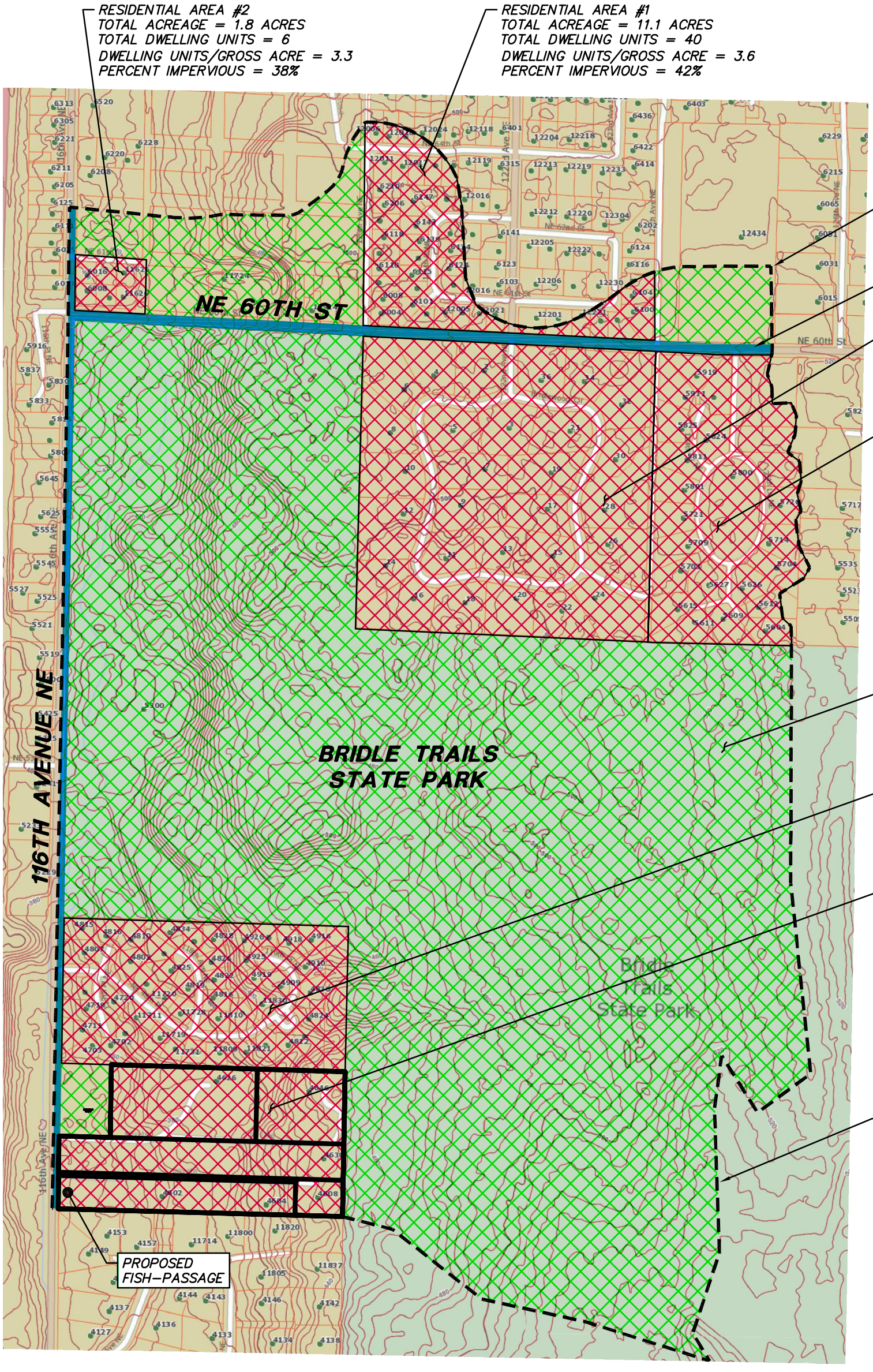
Flow Frequency Analysis

Time Series File:yarrowcreek.tsf
Project Location:Sea-Tac

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
32.91	4	2/09/01 12:45	96.85	1	100.00	0.990
18.15	7	1/06/02 1:00	55.91	2	25.00	0.960
55.91	2	12/08/02 17:15	39.49	3	10.00	0.900
13.19	8	8/26/04 0:45	32.91	4	5.00	0.800
39.49	3	11/17/04 5:00	27.26	5	3.00	0.667
26.62	6	1/18/06 15:00	26.62	6	2.00	0.500
27.26	5	11/24/06 1:00	18.15	7	1.30	0.231
96.85	1	1/09/08 6:30	13.19	8	1.10	0.091
Computed Peaks			83.20		50.00	0.980

100-year Peak Flow for a Tributary Basin of 343.8 Acres = 96.85 cubic feet per second

Tributary Area Exhibit



TOTAL BASIN AREA TRIBUTARY TO PROPOSE CULVERT = 343.8 ACRES
TOTAL RESIDENTIAL IMPERVIOUS AREA = 25.3 ACRES
TOTAL RESIDENTIAL PERVIOUS AREA = 83.3 ACRES
TOTAL ROADWAY AREA = 6.6 ACRES
TOTAL FORESTED AREA = 228.6 ACRES

100-YEAR STORM FLOW = 96.85 CFS

Bridlestone Estates

City of Kirkland, WA

November 2, 2015

TOPOGRAPHY SOURCE: KING COUNTY IMAP

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KCRTS is the "Effective Impervious Area" (EIA), the total impervious area multiplied by the **effective impervious fraction**. See Table 3.2.2.E, p. 3-29 for effective impervious fractions that apply to standard impervious surfaces. Table 1.2.3.C lists effective impervious factions for alternative materials and approaches.

Non-effective impervious area (i.e., total impervious area less EIA) is assumed to have the same hydrologic response as the immediately surrounding pervious area. For example, for existing residential areas with rooftops draining to splash pads on lawns or landscaping, the non-effective portion of the roof areas would be treated as pasture for predevelopment conditions (if DU/GA < 4.0) and grass for post-development conditions. *Note: Credits for infiltration/dispersion of downspouts on individual lots in proposed single family residential subdivisions are applied separately on a site-specific basis (see Note 3,* Table 3.2.2.E*).*

The effective impervious fraction can be selected from Table 3.2.2.E or determined from detailed ***site*** surveys. With the exception of figures for compacted gravel and dirt roads and parking lots, the figures in Table 3.2.2.E are average figures cited by the USGS (Dinicola, 1990).

TABLE 3.2.2.D PERCENT IMPERVIOUS COVERAGE FOR EXISTING RESIDENTIAL AREAS

Dwelling Units/Gross Acre	% Impervious[1]	Dwelling Units/Gross Acre	% Impervious
1.0 DU/GA	15[2]	4.5 DU/GA	46
1.5 DU/GA	20	5.0 DU/GA	48
2.0 DU/GA	25	5.5 DU/GA	50
2.5 DU/GA	30	6.0 DU/GA	52
3.0 DU/GA	34	6.5 DU/GA	54
3.5 DU/GA	38	7.0 DU/GA	56
4.0 DU/GA	42	7.5 DU/GA	58
For PUDs, condominiums, apartments, commercial businesses, and industrial areas, percent impervious coverage must be computed.			

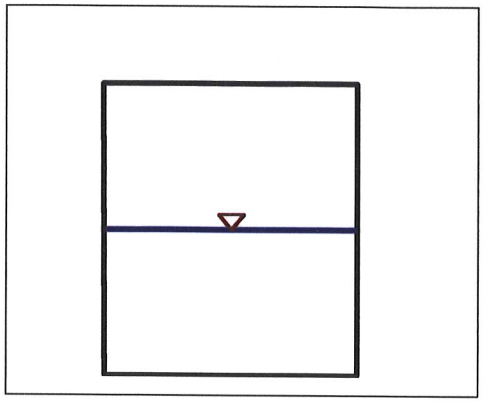
Notes:

[1] Includes streets and sidewalks.

[2] These figures should be adjusted by the effective impervious fraction given in Table 3.2.2.E, if applicable. Values from Table 3.2.2.E may be interpolated as necessary.

Ditch

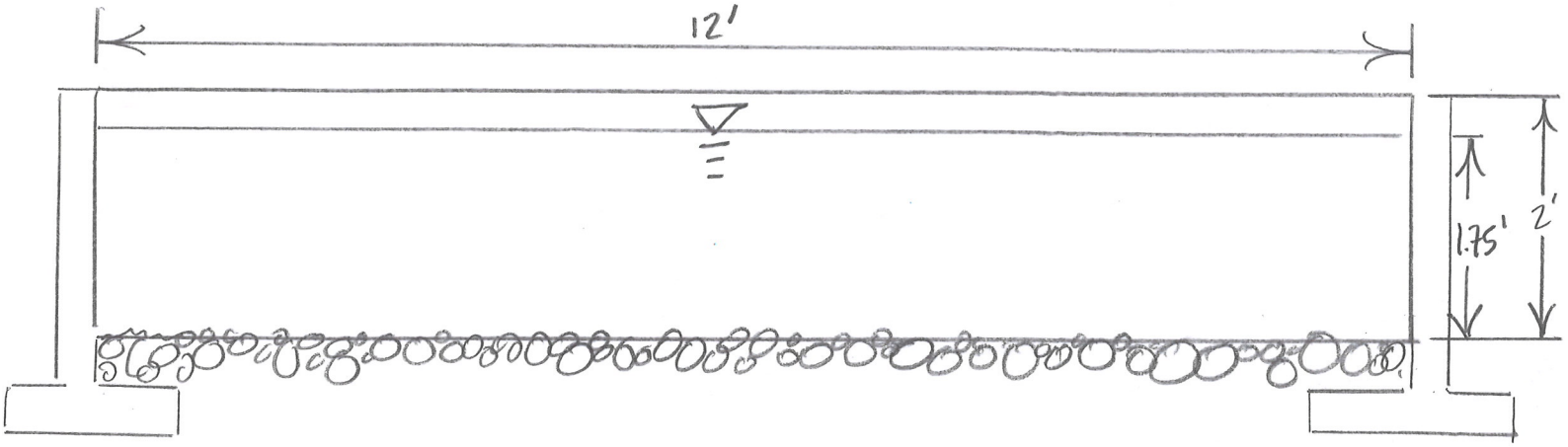
	Input	Output	
Q (cfs)	0.00	96.51	
n	0.028	0.028	
B (ft)	12.00	12.00	Trap.
LSSlope (X:1)	0.00	0.00	
RSSlope (X:1)	0.00	0.00	
y (ft)	1.75	1.75	
S (ft/ft)	0.005	0.005	



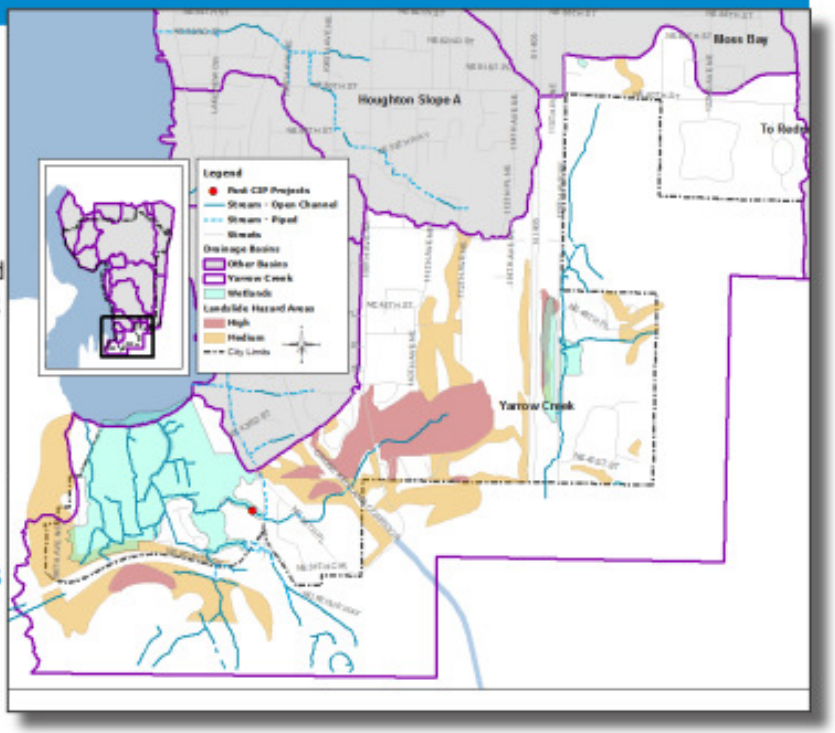
A (sf)	21.003		
Pw (ft)	15.500	V (ft/s)	4.595
R (ft)	1.355		

Job: Bridlestone Estates
By: Beau J Willert

Description: Wetland Swale Capacity
Date: 11/2/2015



Yarrow Creek
Basin Report Card



The Yarrow Creek basin is a large basin that spans over both Kirkland and Bellevue. The area within the City of Kirkland is 579.2 acres and contains the mouth of Yarrow Creek. The majority of the basin is developed for single family use. The existing amount of impervious within this basin is the lowest in the City at 20.8%. This is in part due to large areas of open space, such as Yarrow Bay wetland and Watershed Park, where limited or no development is allowed.

Land/Streamside Conditions

The primary soil type is classified as Type D soil, which is a low infiltrating soil including clay and soils with a permanently high water table or hard pan. This type of soil does not infiltrate, which can lead to larger runoff volumes in storm events.

Approximately 15 to 20% of the basin is covered in both moderate and high landslide hazard areas. These areas slope greater than 15% and likely have groundwater near the surface underlain with impermeable surfaces.

A large wetland complex is located at the mouth of Yarrow Creek. This wetland is 83 acres and rated as highest quality for all wetland functions. This wetland is a critical filter of contaminants prior to discharging into Lake Washington, a storage area for flood waters during storm events, and a home to many fish and wildlife species. There are additional smaller, medium quality wetlands located east of I-405.

50.7% of the Yarrow Creek basin is covered in forest, which is the third highest level of coverage in the city. Forest coverage is important because it reduces the amount of flow and pollutants discharged to streams and lakes. The City is working on an urban forestry plan to improve forest coverage citywide.

There is a nearly continuous greenbelt that connects Yarrow Creek with Cochran Springs Creek and Watershed Park. This enables wildlife to move freely between a variety of upland

LAND CHARACTERISITCS	
Basin Area	579.2 acres
Highest Elevation	534 feet
Lowest Elevation	18 feet
STREAM CHARACTERISTICS	
Total Length of Channel	7.7 miles
In Pipe	0.9 miles
Open Channel	6.8 miles
LAND COVER	
Existing Impervious	20.8%
Built-out Impervious	22.9%
Forest Cover	50.7%
LAND USE	
Single Family Residential	51.4%
Commercial	8.0%
Open Space/Park	29.0%

November 2014